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(54) **ELECTRICAL CONNECTOR SYSTEM HAVING AN INSULATOR HOLDING TERMINALS**

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H01R 24/62 (2011.01)

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CPC ***H01R 13/648*** (2013.01); ***H01R 13/6581*** (2013.01); ***H01R 24/62*** (2013.01)

(58) **Field of Classification Search**
CPC H01R 13/65802; H01R 13/658; H01R 23/6873; H01R 23/7073
USPC 439/607.01, 607.35, 607.45, 607.46, 439/607.5, 607.51, 660
See application file for complete search history.

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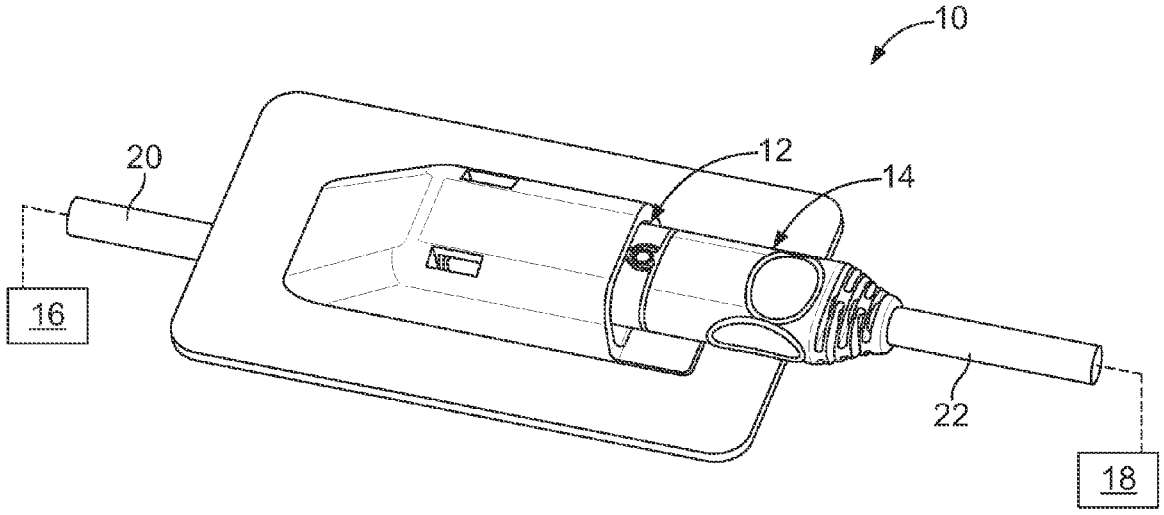
(57) **ABSTRACT**

An electrical connector is provided for terminating a plurality of electrical conductors. The electrical connector includes a terminal subassembly having terminals configured to be electrically connected to the electrical conductors. The terminal subassembly has an insulator holding the terminals. The terminal subassembly has a mating interface where mating surfaces of the terminals mate with a mating connector. The mating interface of the terminal subassembly is approximately flat. The electrical connector also includes a metal shell holding the terminal subassembly. The metal shell has the cross-sectional shape of an oval.

16 Claims, 7 Drawing Sheets



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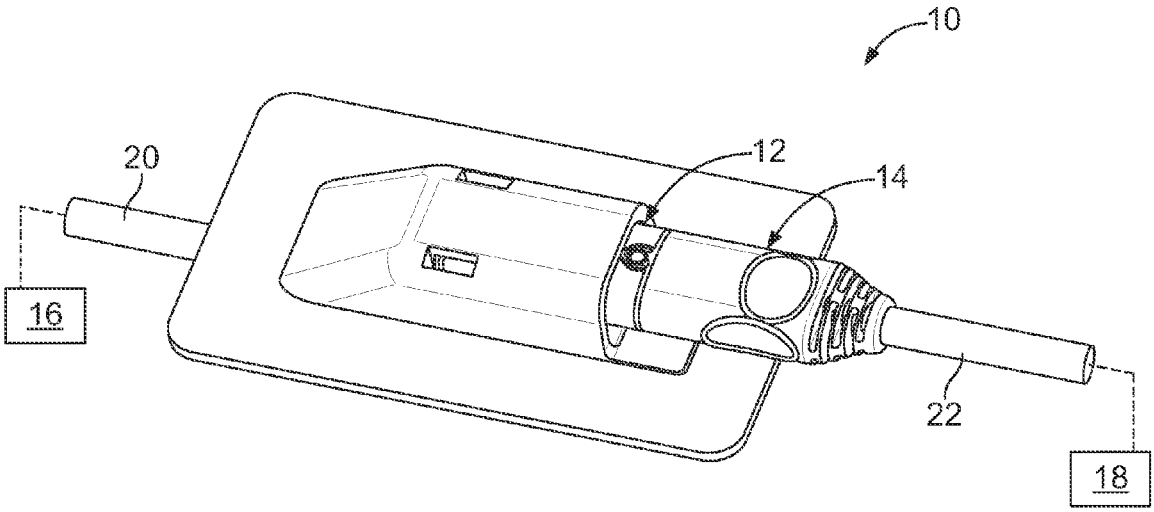

FIG. 1

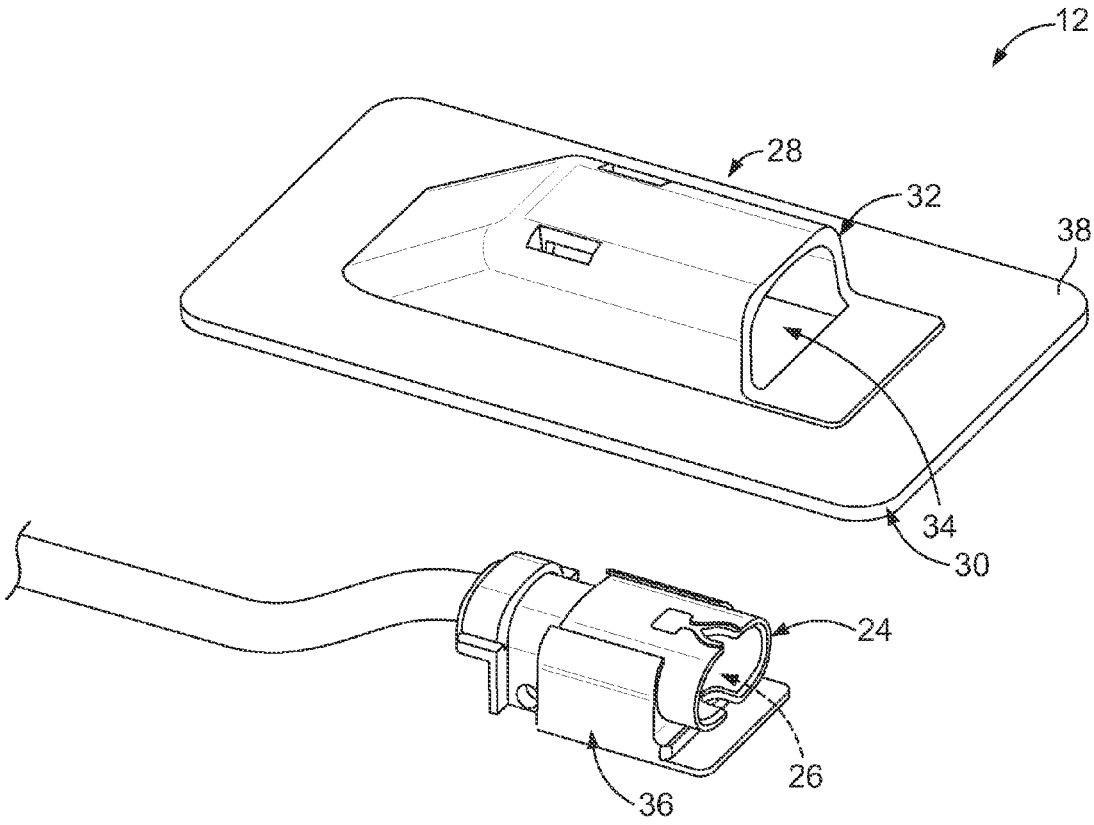

FIG. 2

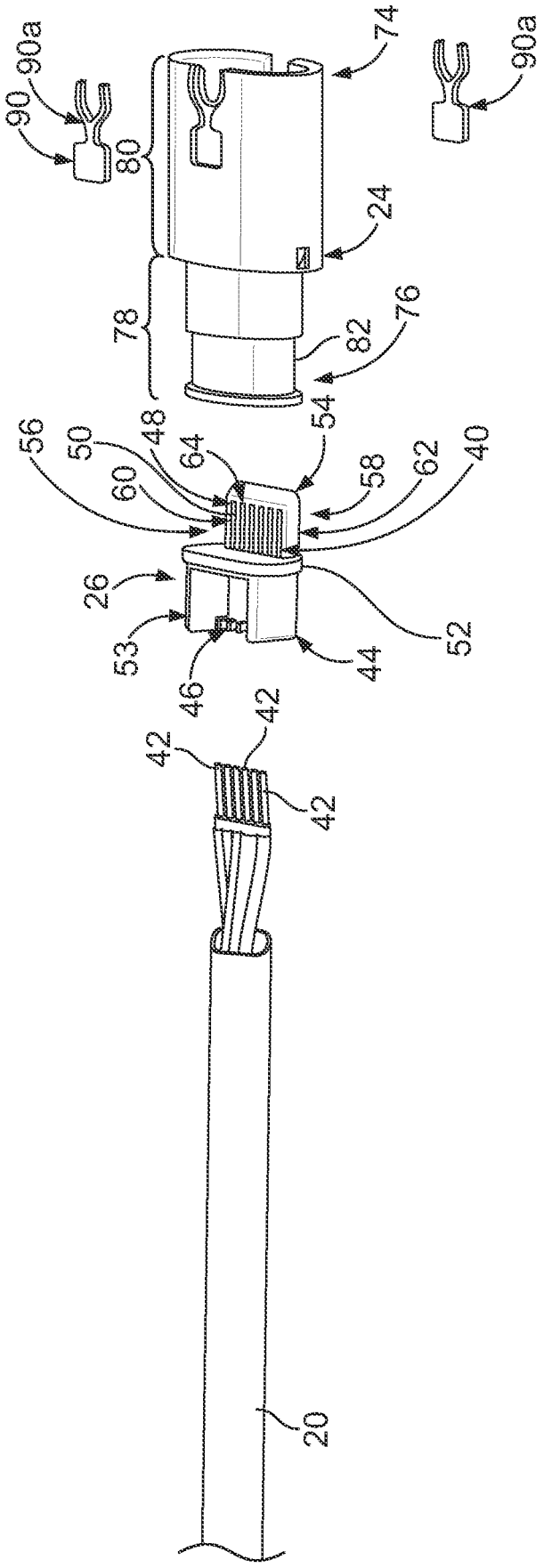
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FIG. 3

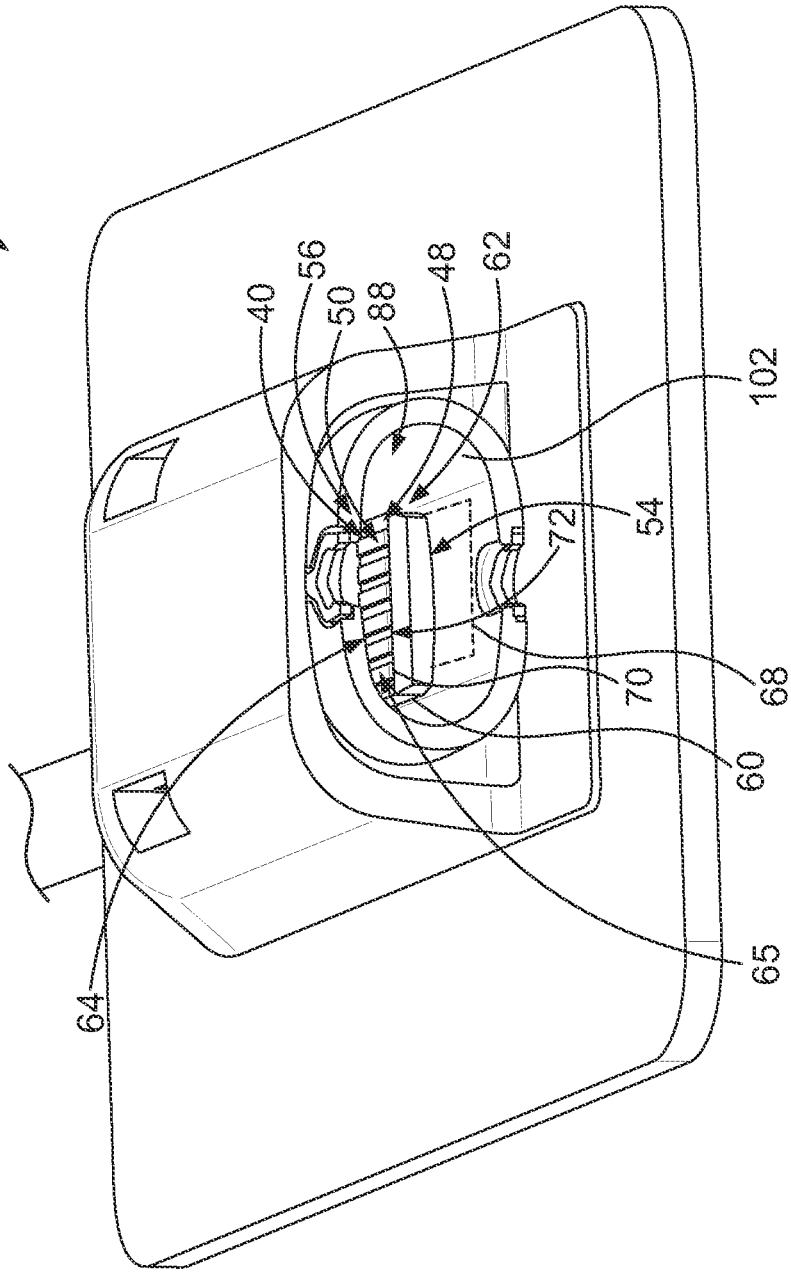
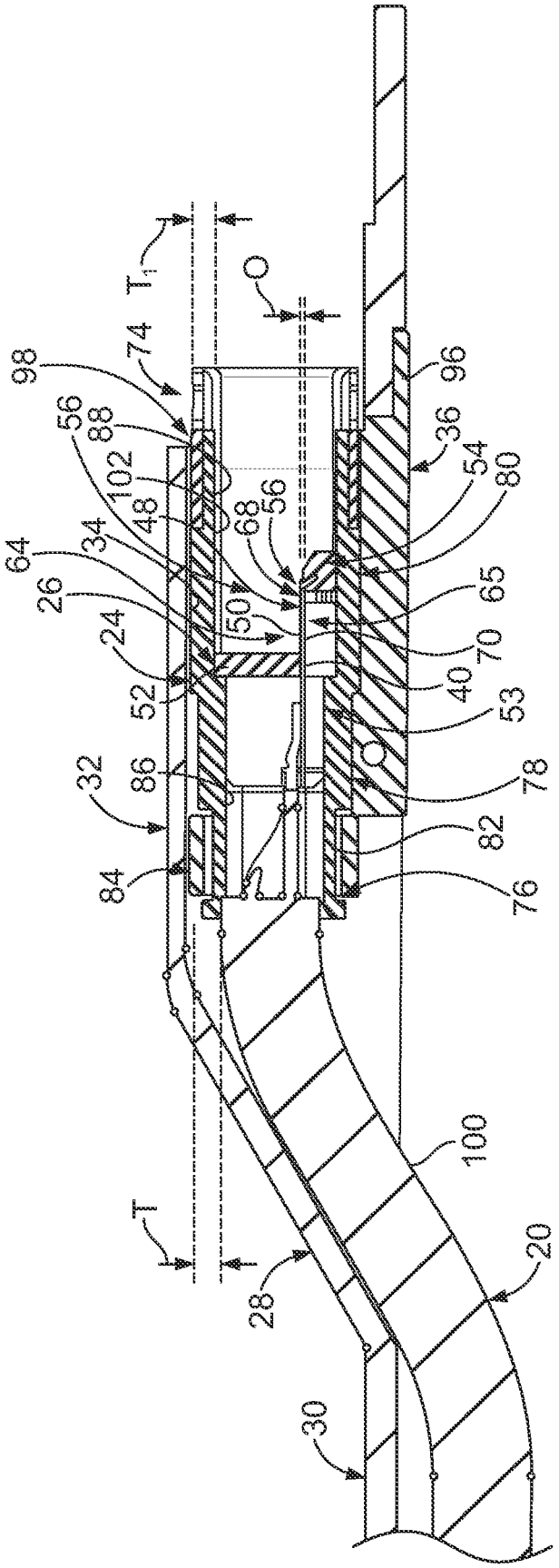


FIG. 4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64
34
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28
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FIG. 5

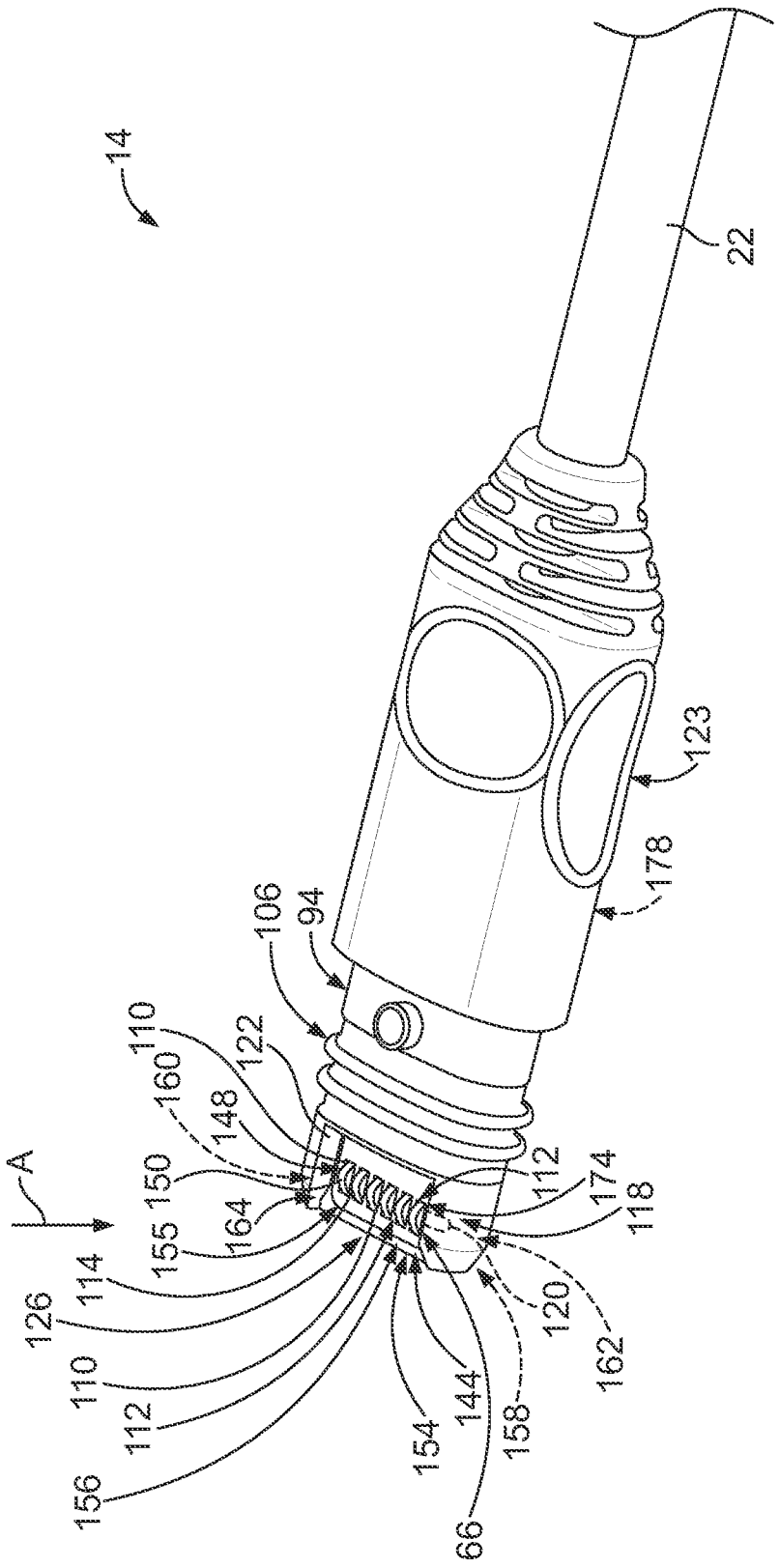
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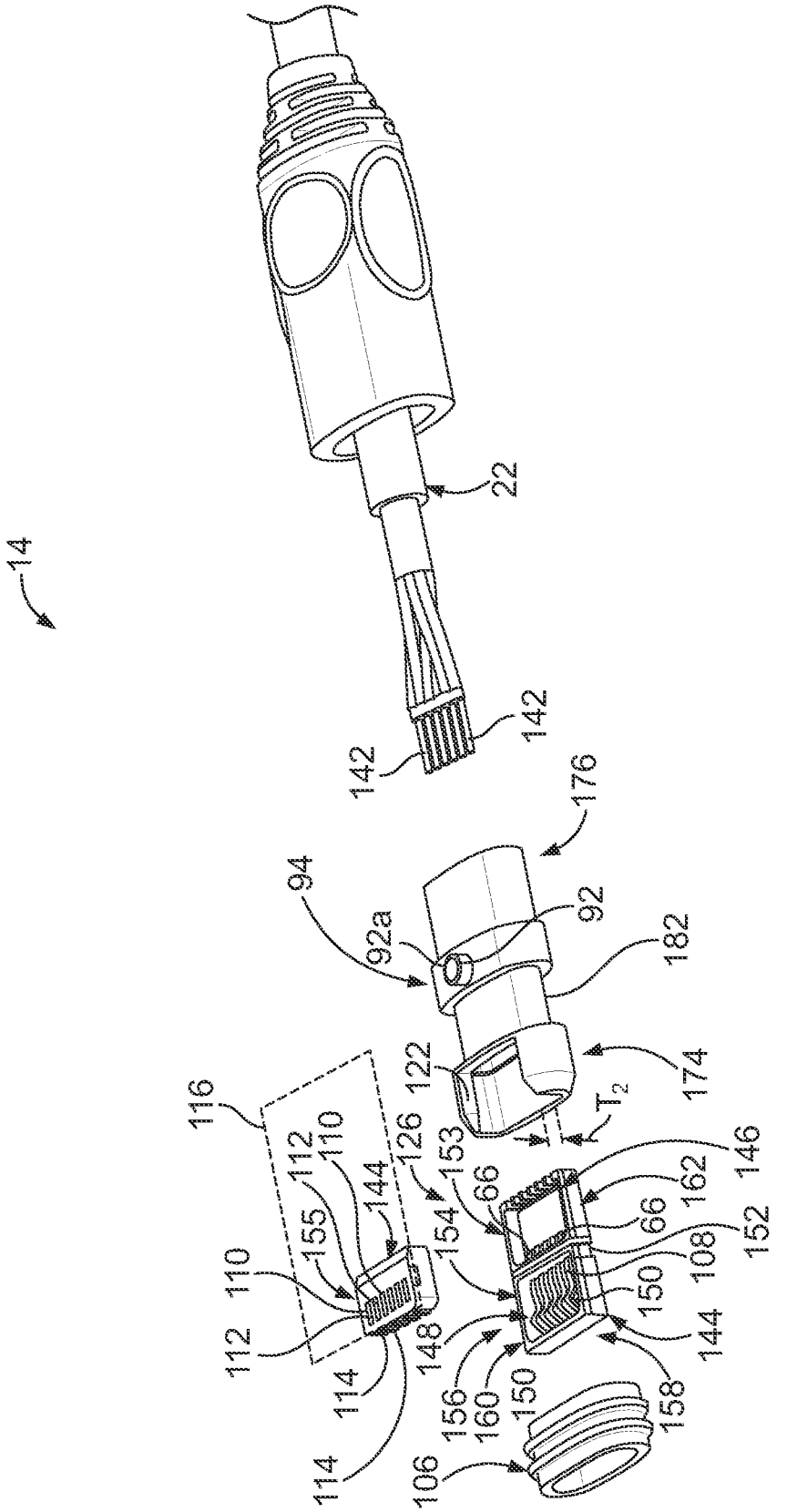
FIG. 6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158
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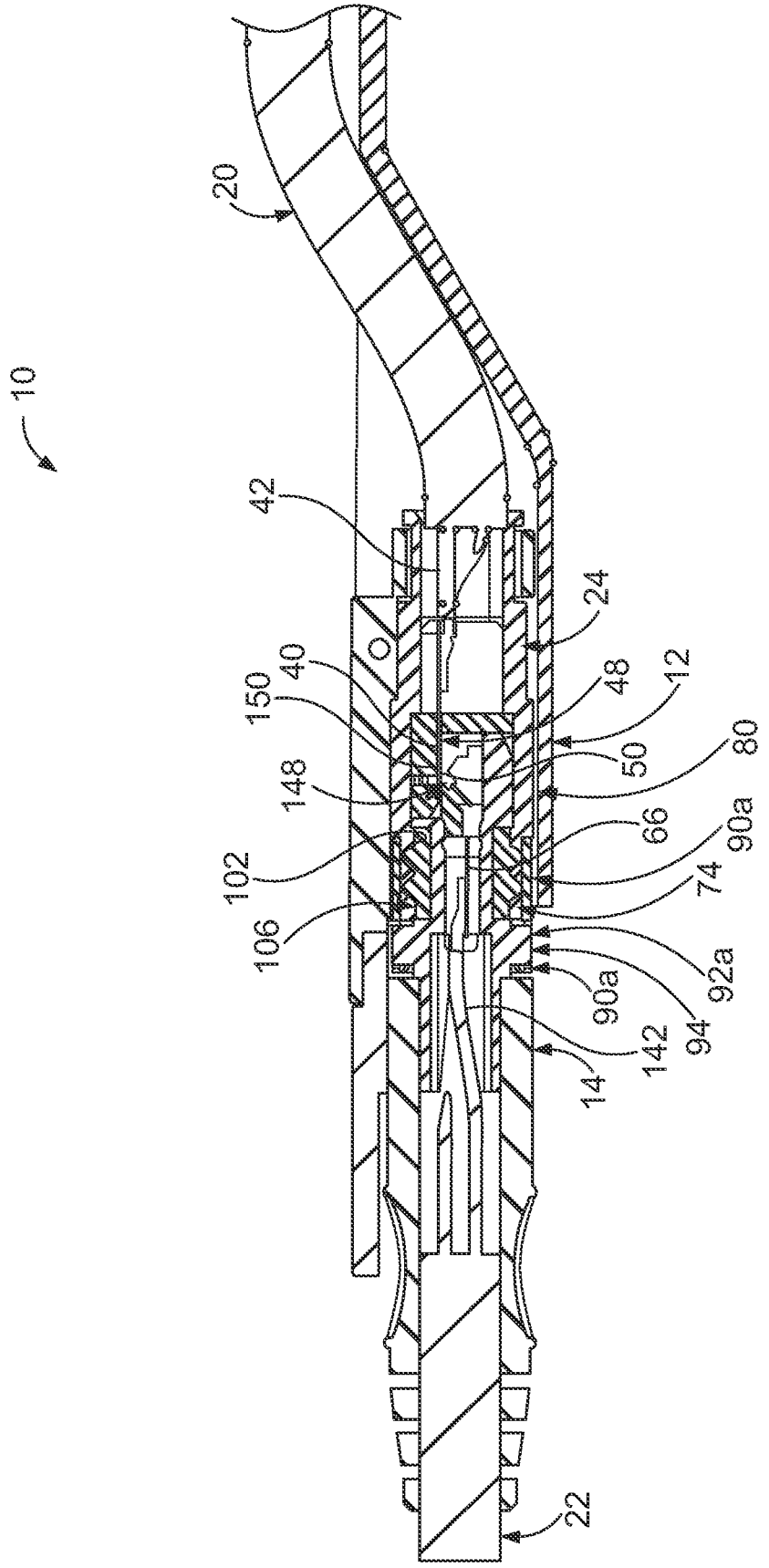
106

FIG. 7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92a
90a
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14
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FIG. 8

ELECTRICAL CONNECTOR SYSTEM HAVING AN INSULATOR HOLDING TERMINALS

BACKGROUND OF THE INVENTION

The subject matter described and/or illustrated herein relates generally to electrical connectors.

Electrical connector system are used to electrically connect a wide variety of electronic devices. But, known electrical connectors are not without disadvantages. For example, at least some known electrical connectors are not shielded to meet EMI/RFI demands in the field, which may cause excessive interference with the data signals. Moreover, and for example, at least some known electrical connectors have a circular shape that may be easily snagged. Such circular electrical connectors may also have a large enough profile that causes difficulty mounting the circular electrical connector to a wearable article. For example, the circular electrical connector may be too bulky and/or may cause irritation to a person who is wearing the wearable article. Another problem with circular electrical connectors is that the terminals thereof are not capable of being cleaned in the field. For example, the mating interfaces of at least some known circular electrical connectors are shrouded, which enables collection of debris, which can not be easily cleaned in the field. Attempts to clean such interfaces typically lead to damage of the terminals of the connector.

BRIEF DESCRIPTION OF THE INVENTION

In one embodiment, an electrical connector is provided for terminating a plurality of electrical conductors. The electrical connector includes a terminal subassembly having terminals configured to be electrically connected to the electrical conductors. The terminal subassembly has an insulator holding the terminals. The terminal subassembly has a mating interface where mating surfaces of the terminals mate with a mating connector. The mating interface of the terminal subassembly is approximately flat. The electrical connector also includes a metal shell holding the terminal subassembly. The metal shell has the cross-sectional shape of an oval.

In another embodiment, an electrical connector is provided for terminating a plurality of electrical conductors. The electrical connector includes an insulator having grooves and ribs that extend between adjacent grooves. The electrical connector also includes terminals held by the insulator. The terminals have terminating ends that are configured to be electrically connected to the electrical conductors. The terminals have mating ends that include mating surfaces where the terminals are configured to mate with a mating connector. The mating ends of the terminals are deflectable springs that are aligned with corresponding grooves such that the mating ends are configured to be deflected into the corresponding grooves. The ribs are configured to protect the mating ends of the terminals from over-deflection. The electrical connector also includes a metal shell holding the terminal subassembly.

In another embodiment, an electrical connector system includes a first connector having a first terminal subassembly and a first metal shell. The first terminal subassembly is held by the first metal shell and includes a first group of terminals. The first metal shell includes a sealing ring. The electrical connector system includes a second connector configured to mate with the first connector. The second connector has a second metal shell and a second terminal subassembly that is held by the second metal shell. The second terminal subassembly includes a second group of terminals that is configured to mate with the first group of terminals of the first connector. The second metal shell includes a terminating segment and a tunnel that extends outward from the terminating segment. The tunnel has an open end defined by at least one interior surface of the tunnel. The first metal shell is configured to be received within the open end of tunnel such that the first and second connectors mate together within the tunnel. The sealing ring is configured to sealingly engage with the interior surface of the tunnel to seal the open end of the tunnel when the first and second connectors are mated together within the tunnel.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an exemplary embodiment of an electrical connector system.

FIG. **2** is a partially exploded perspective view of an exemplary embodiment of an electrical connector of the electrical connector system shown in FIG. **1**.

FIG. **3** is an exploded perspective view of the electrical connector shown in FIG. **2**.

FIG. **4** is a perspective view of the electrical connector shown in FIGS. **2** and **3** illustrating the electrical connector as assembled.

FIG. **5** is a cross-sectional view of the electrical connector shown in FIGS. **2-4**.

FIG. **6** is a perspective view of an exemplary embodiment of another electrical connector of the electrical connector system shown in FIG. **1**.

FIG. **7** is an exploded perspective view of the electrical connector shown in FIG. **6**.

FIG. **8** is a cross-sectional view of the connector system shown in FIG. **1**.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** is a perspective view of an exemplary embodiment of an electrical connector system **10**. The electrical connector system **10** includes electrical connectors **12** and **14** that mate together to form an electrical connection therebetween. The electrical connector system **10** is provided along an electrical path between two electronic devices **16** and **18** for providing a separable electrical connection between the electronic devices **16** and **18**. As will be described below, the electrical connector system **10** is optionally mounted to a wearable article (not shown), such as, but not limited to, a vest, a shirt, a jacket, pants, trousers, a boot, a shoe, a helmet, a hat, a cap, a coat, armor, and/or the like. Each of the electrical connectors **12** and **14** may be referred to herein as a "mating connector", a "first" connector, and/or a "second" connector.

Each of the devices **16** and **18** may be any type of electronic device. In an exemplary embodiment, the electronic device **16** constitutes a battery pack and the electronic device **18** constitutes an LED array that may be powered by the battery pack. Other types of electronic devices may be interconnected by the electrical connector system **10** in other embodiments.

In the illustrated embodiment, the connector **12** is electrically connected to the electronic device **16** via a cable **20**. The cable **20** may have any length. In other words, the connector **12** terminates the electrical cable **20**. In alternative to the cable **20**, the connector **12** may be mounted directly to the electronic device **16** or may be electrically connected to the electronic device **16** via an e-textile (not shown) that includes fabrics that enable computing, digital components, electrical pathways, and/or electronic devices to be embedded therein. Specifically, the e-textile provides a wearable article with

wearable technology that allows for the incorporation of built-in technological elements into the fabric of the wearable article. The wearable article may constitute intelligent clothing or smart clothing.

The connector **14** is also shown in the illustrated embodiment as being electrically connected to the corresponding electronic device **18** via a corresponding cable **22**. But, in other embodiments, the connector **14** may be mounted directly to the electronic device **16** or may be electrically connected to the electronic device **16** via the electrical conductors (not shown) of an e-textile (not shown).

FIG. **2** is a partially exploded perspective view of an exemplary embodiment of the electrical connector **12**. The connector **12** includes a metal shell **24** and a terminal subassembly **26** (best seen in FIGS. **3** and **5**) held by the metal shell **24**. Optionally, the connector **12** includes a holder **28**. For example, as discussed above, the electrical connector system **10** is optionally held by a wearable article. In the illustrated embodiment, the holder **28** is used to mount the connector **12** of the connector system **10** to the wearable article. The holder **28** includes a base **30** and a shroud **32**. The shroud **32** defines a chamber **34** of the holder **28**. As will be described below with reference to FIG. **5**, the connector **12** is held by the holder **28** such that the connector **12** extends within the chamber **34**. The connector **12** optionally includes a fixture **36** that cooperates with the holder **28** for securely holding the connector **12** within the chamber **34**.

The holder **28** is mounted to the wearable article to thereby mount the connector **12** to the wearable article. The holder **28** may be mounted to the wearable article using any type of connection, such as, but not limited to, by being sewn to the wearable article, by being adhered to the wearable article using an adhesive, and/or the like. In the illustrated embodiment, the base **30** of the holder **28** includes a flange **38** through which a thread may be routed to sew the holder **28** to the wearable article. Optionally, the holder **28** may be mounted to the wearable article within and/or under a pocket and/or other covering of the wearable article. For example, a flap may cover a portion or all of the holder **28** and/or the connector **12**.

FIG. **3** is an exploded perspective view of the electrical connector **12**. The holder **28** and fixture **36** are not shown in FIG. **3**. The connector **12** includes the terminal subassembly **26** and the metal shell **24** that holds the terminal subassembly **26**. The terminal subassembly **26** has a plurality of terminals **40** that are configured to be electrically connected to corresponding electrical conductors **42** of the cable **20**. The terminal subassembly **26** has an insulator **44** that holds the terminals **40**. The insulator **44** electrically isolates the terminals **40** from the metal shell **24** and may provide impedance control, such as by positioning the terminals **40** at predetermined locations to achieve a target characteristic impedance. In the illustrated embodiment, the insulator **44** is manufactured from a single piece, but the insulator **44** may alternatively be manufactured from two or more pieces that connect together to define the insulator **44**. The insulator **44** may be manufactured from any number of pieces. The terminal subassembly **26** may be referred to herein as a "first" and/or a "second" terminal subassembly.

The terminals **40** have terminating ends **46** and mating ends **48**. The mating ends **48** have mating surfaces **50** configured for mating with the electrical connector **14** (FIGS. **1** and **6-8**). The terminating ends **46** are configured to be electrically connected to corresponding electrical conductors **42** of the cable **20**. In an exemplary embodiment, the terminating ends **46** are configured to be ultrasonically welded to the electrical conductors **42**. Alternatively, the terminating ends **46** may be terminated to the electrical conductors **42** in a different manner, such as by soldering, crimping, and/or by other means. Optionally, the terminating ends **46** may be compression crimped to the electrical conductors **42**. Each of the terminals **40** may be a signal terminal, a ground terminal, or a power terminal.

The insulator **44** includes a base **52**, a terminating segment **53** that extends outward from the base **52**, and a platform **54** that extends outward from the base **52**. The terminating ends **46** of the terminals **40** extend along the terminating segment **53** of the insulator **44** for electrical connection to the corresponding electrical conductors **42** of the cable **20**.

The platform **54** includes a terminal side **56**, an opposite side **58**, and two side ends **60** and **62** that each extend from the terminal side **56** to the opposite side **58**. The mating ends **48** of the terminals **40** are arranged along the platform **54**. Specifically, the mating ends **48** of the terminals **40** are positioned on the terminal side **56** of the platform **54** such that the mating surfaces **50** are arranged along the terminal side **56** of the platform **54**. The mating ends **48** of the terminals **40** rest on the terminal side **56** of the platform **54** such that the terminal side **56** supports the mating ends **48** of the terminals **40**.

The mating surfaces **50** define a mating interface **64** of the terminal subassembly **26** where the mating surfaces **50** mate with corresponding terminals **66** (FIGS. **6-8**) of the connector **14**. As described above, the mating surfaces **50** of the terminals **40** are arranged along the terminal side **56** of the platform **54**. Accordingly, the mating interface **64** of the connector **12** extends on the terminal side **56** of the platform **54**.

The mating interface **64** of the terminal subassembly **26** is approximately flat. For example, and referring now to FIGS. **4** and **5**, the mating surface **50** of each of the terminals **40** is approximately flat. As best seen in FIG. **4**, the mating ends **48**, and thus the mating surfaces **50**, of the terminals **40** are arranged side by side in a row **65**. As best seen in FIG. **5**, the mating surfaces **50** of the terminals **40** extend approximately within the same plane **68**. The approximately flat shapes of the mating surfaces **50** and the alignment within the common plane **68** provides the mating interface **64** of the connector **12** as approximately flat. The approximately flat mating interface **64** may provide a wipeable and/or cleanable surface for cleaning the mating surfaces **50** of the terminals **40**. For example, a user may use their thumb, a cloth, and/or the like to wipe across the mating interface **64** to clear debris, dirt, other contaminants, and/or the like from the terminals **40**. Moreover, the approximately flat mating interface **64** may trap less dirt, debris, other contaminants, and/or the like than the mating interfaces of at least some known electrical connectors. The approximately flat mating interface **64** may thus enable the mating surfaces **50** of the terminals **40** to be more reliable and/or be more easily cleaned than the terminals of at least some known electrical connectors. For example, the approximately flat mating interface **64** may enable the mating surfaces **50** of the terminals **40** to be cleaned without damaging the terminals **40**. The approximately flat mating interface **64** may provide the connector **12** with a lower profile than at least some known electrical connectors.

Optionally, the terminal side **56** of the platform **54** includes grooves **70** that receive the mating ends **48** of corresponding terminals **40** therein. The mating surfaces **50** of the terminals **40** may be offset above the terminal side **56** of the platform **54** or may be flush (i.e., coplanar) with the terminal side **56**. For example, in the illustrated embodiment, the mating surfaces **50** are offset O (not labeled in FIG. **4**) above segments **72** (not visible in FIG. **5**) of the terminal side **56** that extend between the mating ends **48** of the terminals **40**. The grooves **70** and terminals **40** have a relative size that is selected to provide the offset O with a predetermined value. In other embodiments,

the terminal side **56** of the platform **54** does not include the grooves **70** and the thickness of the mating ends **48** of the terminals **40** is selected to provide the offset O with a predetermined value. The offset O may have any value. As discussed above, in some alternative embodiments, the grooves **70** and terminals **40** have a relative size that is selected such that the mating surfaces **50** of the terminals **40** are flush (i.e., coplanar) with the segments **72** of the terminal side **56**. In other words, the offset O may have a value of approximately zero in some alternative embodiments.

Referring again to FIG. **3**, the metal shell **24** extends a length from a mating end **74** to an opposite terminating end **76**. The metal shell **24** includes a terminating segment **78** and a tunnel **80** that extends outward from the terminating segment **78**. The terminating segment **78** includes the terminating end **76** of the metal shell **24**. The tunnel **80** includes the mating end **74**. The metal shell **24** is configured to receive the electrical conductors **42** of the cable **20** through the terminating end **76** of the terminating segment **78**. The terminals **40** of the connector **12** are configured to mate with the electrical connector **14** (FIGS. **1** and **6-8**) within the tunnel **80**. Optionally, the terminating segment **78** of the metal shell **24** includes a groove **82** that receives a flange **84** (FIG. **5**) of the fixture **36** (FIGS. **2** and **5**) therein to facilitate holding of the metal shell **24** by the fixture **36**. The metal shell **24** may be referred to herein as a "first" and/or a "second" metal shell.

The metal shell **24** may include any metallic materials, such as, but not limited to, aluminum, copper, gold, silver, nickel, titanium, magnesium, platinum, another metal, and/or the like. In some embodiments, the metal shell **24** includes an aluminum alloy, a copper alloy, a gold alloy, a silver alloy, a nickel alloy, a titanium alloy, a magnesium ally, a platinum alloy, another metal alloy, and/or the like. Moreover, in some embodiments, an approximate entirety or a majority of the metal shell **24** is fabricated from one or more metals and/or metal alloys. In some embodiments, at least 90% of the metal shell **24** is fabricated from one or more metals and/or metal alloys. In the exemplary embodiment of the metal shell **24**, an approximate entirety of the metal shell **24** is fabricated from one or more metals and/or metal alloys. Optionally, the metal shell **24** includes a base material (not shown) that is coated (e.g., plated and/or the like) with one or more different materials, whether or not the base material and/or the coating includes a metal and/or a metal alloy. One example of fabricating less than an approximate entirety of the metal shell **24** from one or more metals and/or metal alloys includes providing the metal shell **24** with a base material of one or more metals and/or metal alloys that is coated with one or more non-metallic materials, or vice versa. Any non-metallic materials that the metal shell **24** includes may or may not be electrically conductive.

The metal shell **24** is electrically conductive. Specifically, at least a portion of the metal shell **24** is electrically conductive such that the metal shell **24** defines an electrical path through the connector **12**. In some embodiments, an approximate entirety of the metal shell **24** is electrically conductive. In other embodiments, one or more segments (e.g., a coating, a base material, and/or the like) is not electrically conductive. The electrical conductivity of the metal shell **24** enables the metal shell **24** to electrically shield the terminal subassembly **26**. The electrical shielding may prevent or reduce electromagnetic interference (EMI) and/or radio frequency interference (RFI) on the signal paths defined through the connector **12**. Such electrical shielding may allow relatively high speed data to be uninterrupted by the connector **12**.

In the illustrated embodiment, the metal shell **24** is manufactured from a single piece, but the metal shell **24** may alternatively be manufactured from two or more pieces that connect together to define the metal shell **24**. For example, the meal shell **24** may be defined by two portions (e.g., halves) that both include a portion of the terminating segment **78** and the tunnel **80** and that connect together to define the complete terminating segment **78** and the complete tunnel **80**. Moreover, in the illustrated embodiment, the tunnel **80** is integrally formed with the terminating segment **78**. But, the tunnel **80** may alternatively be a discrete component of the metal shell **24** that can be removably connected to the terminating segment **78**. For example, the tunnel **80** may receive therein an end of the terminating segment **78** that is opposite the terminating end **76** to hold the tunnel **80** and terminating segment **78** together.

Referring again to FIG. **5**, the terminating segment **78** of the metal shell **24** includes a cavity **86** that receives the terminating segment **53** of the terminal subassembly **26** therein. The cavity **86** extends through the length of the terminating segment **78** of the metal shell **24** such that the terminating segment **78** is open at the terminating end **76**. The tunnel **80** extends outward from the terminating segment **78** to the mating end **74**. The tunnel **80** includes an opening **88** that extends through the length of the tunnel **80** such that the opening **88** fluidly communicates with the cavity **86** and such that the tunnel **80** is open at the mating end **74**. The tunnel **80** is configured to receive a portion of the electrical connector **14** into the opening **88** through the mating end **74**.

The terminating segment **78** has a thickness T. The tunnel **80** has a thickness T_1. The thicknesses T and T_1 may each have any value. Various parameters of the metal shell **24** may be selected to provide the metal shell **24**, and thus the connector **12**, with a predetermined strength. Examples of such various parameters include, but are not limited to, the thickness T, the thickness T_1, the particular metallic materials of the metal shell, and/or the like. The predetermined strength of the metal shell **24** may reduce the likelihood that the metal shell **24** will structurally fail (e.g., fracture, break, collapse, and/or the like) during use within relatively rugged environments, such as, but not limited to, use when mounted to a wearable article, use within battlefields or other combat situations, field use, use within manufacturing facilities, use within construction sites, and/or the like. The predetermined strength of the metal shell **24** may enable the metal shell **24** to better protect the terminal sub-assembly **26** in relatively rugged environments. The predetermined strength of the metal shell **24** may enable the metal shell **24** to provide an increased amount of protection to the terminal subassembly **26** than at least some known electrical connectors. Examples of the thicknesses T and T_1 include, but are not limited to, between approximately 0.5 mm and approximately 2.0 mm, at least approximately 0.5 mm, and/or the like.

Referring again to FIG. **3**, the tunnel **80** optionally includes securing features **90** for securing the connector **14** to the connector **12** when the connectors **12** and **14** are mated together. In the illustrated embodiment, the securing features **90** include electrical contacts **90***a* that are configured to mechanically and electrically connect with electrical pins **92***a* (FIGS. **6** and **8**) of a metal shell **94** (FIGS. **6-8**) of the connector **14** (FIGS. **1** and **6-8**) to electrically and mechanically connect the metal shell **24** of the connector **12** to a metal shell **94** of the connector **14**. Other types of securing features **90** may additionally or alternatively be used to electrically and/or mechanically connect the metal shells **24** and **94** together.

Referring now to FIGS. **3** and **4**, the metal shell **24** has the cross-sectional shape of an oval. Specifically, the metal shell **24** has the cross-sectional shape of an oval taken along a cross section that extends approximately perpendicular to the

length of the metal shell **24**. In the illustrated embodiment, both the terminating segment **78** and the tunnel **80** have the cross-sectional shape of an oval. Alternatively, only the tunnel **80** or only the terminating segment **78** has the cross-sectional shape of an oval. As used herein, the term "oval" means a shape like an egg, an elliptical shape, an oblong shape, a figure that resembles two semicircles joined by a rectangle (e.g., like a cricket infield, an oval racing track, and/or the like), a rectangle with rounded corners, and/or the like. The oval cross-sectional shape of the metal shell **24** may facilitate providing the metal shell **24**, and thus the connector **12**, with a relatively low profile, which may facilitate use of the connector **12** when held by the wearable article. The oval cross-sectional shape of the metal shell **24** may provide the metal shell **24** with a lower profile than at least some known electrical connectors.

Referring again to FIG. **5**, the metal shell **24** is held by the fixture **36**. Specifically, in the illustrated embodiment, the flange **84** of the fixture **36** is received within the groove **82** of the metal shell **24** with a snap-fit connection to hold the metal shell **24** to the fixture **36**. The fixture **36** is held by the holder **28** such that the metal shell **24** extends within the chamber **34** of the shroud **32** of the holder **28**. The fixture **36** may include one or more tabs **96** and/or other securing features for mechanically connecting the fixture **36** to the holder **28**. The fixture **36** is held by the holder **28** such that the terminating segment **78** of the metal shell **28** extends within the chamber **34** of the holder **28**. The tunnel **80** extends outward from the terminating segment **78** toward an entrance **98** to the chamber **34**. Optionally, the mating end **74** of the tunnel **80** extends past the entrance **98**, as is shown in FIG. **5**. In the illustrated embodiment, an insulator **100** of the cable **20** is sealingly engaged with the metal shell **24** at the terminating end **78** to seal the terminating end **78**. The seal provided by such engagement may enable the connector **12** to be water tight. The shroud **32** and base **30** of the holder **28** also facilitate sealing the terminating end **78**. In addition or alternatively to the engagement between the insulator **100** and the metal shell **24** and/or use of the holder **28**, the connector **12** may include a grommet (not shown) and/or a boot (not shown) that seals the terminating end **78** of the metal shell **24**.

As can be seen in FIG. **5**, the terminating segment **53** of the terminal subassembly **26** is held within the cavity **86** of the terminating segment **78** of the metal shell **24**. The base **52** and platform **54** extend into the opening **88** of the tunnel **80** for mating with the electrical connector **14**. The tunnel **80** surrounds the platform **54** such that the mating interface **64** of the terminal subassembly **26** is exposed within the opening **88** of the tunnel **80** for mating with the connector **14**. The tunnel **80** is spaced apart from the platform **54** along at least three sides of the platform **54**. For example, as is better illustrated in FIG. **4**, an interior surface **102** of the tunnel **80** that defines the opening **88** is spaced apart from the terminal side **56** and the side ends **60** and **62** of the platform **54**.

Although six are shown, the connector **12** may include any number of the terminals **40**. Optionally, four of the terminals **40** may be configured to operate at any universal serial bus (USB) standard, protocol, and/or the like, such as, but not limited to, USB 1.0, USB 2.0, USB 3.0, and/or the like.

FIG. **6** is a perspective view of an exemplary embodiment of the electrical connector **14**. The connector **14** includes the metal shell **94** and a terminal subassembly **126** held by the metal shell **94**. The terminal subassembly **126** has a plurality of the terminals **66**, which are configured to be electrically connected to corresponding electrical conductors **142** (FIG. **7**) of the cable **22**. The terminal subassembly **126** has an insulator **144** that holds the terminals **66**. The insulator **144** electrically isolates the terminals **66** from the metal shell **94** and may provide impedance control, such as by positioning the terminals **66** at predetermined locations to achieve a target characteristic impedance. The terminal subassembly **126** may be referred to herein as a "first" and/or a "second" terminal subassembly. The metal shell **94** may be referred to herein as a "first" and/or a "second" metal shell.

The connector **14** optionally includes a sealing ring **106** that extends around the metal shell **94**. As will be described below, the sealing ring **106** is configured to sealingly engage the tunnel **80** (FIGS. **3-5** and **8**) to seal the tunnel when the connectors **12** and **14** are mated together within the tunnel **80**. The sealing ring **106** may have any size, shape, materials, structure, and/or the like. Optionally, the sealing ring **106** is elastomeric.

FIG. **7** is an exploded perspective view of the electrical connector **14**. The terminals **66** have terminating ends **146** and mating ends **148**. The mating ends **148** have mating surfaces **150** configured for mating with the electrical connector **12** (FIGS. **1-5** and **8**). The terminating ends **146** are configured to be electrically connected to corresponding electrical conductors **142** of the cable **22**. In an exemplary embodiment, the terminating ends **146** are configured to be ultrasonically welded to the electrical conductors **142**. Alternatively, the terminating ends **146** may be terminated to the electrical conductors **142** in a different manner, such as by soldering, crimping, and/or by other means. Optionally, the terminating ends **146** may be compression crimped to the electrical conductors **142**. Each of the terminals **66** may be a signal terminal, a ground terminal, or a power terminal.

The insulator **144** includes a base **152**, a terminating segment **153** that extends outward from the base **152**, a platform **154** that extends outward from the base **152**, and a grate **155**. The terminating ends **146** of the terminals **66** extend along the terminating segment **153** of the insulator **144** for electrical connection to the corresponding electrical conductors **142** of the cable **22**.

The mating ends **148** of the terminals **66** are arranged along the platform **154**, which includes a terminal side **156**, an opposite side **158**, and side ends **160** and **162**. The grate **155** is configured to be received within an opening **108** of the platform **154**. The grate **155** includes grooves **110** and ribs **112** that extend between the grooves **110**. The ribs **112** have tip surfaces **114** that are coplanar (i.e., approximately extend within a common plane **116**), as can be seen in FIG. **7**.

In the illustrated embodiment, the insulator **144** is manufactured from multiple pieces, namely the grate **155** and the remainder of the insulator **144**. Alternatively, the insulator **144** is manufactured from a single piece (e.g., the grate **155** is integrally formed with the remainder of the insulator **144**. The insulator **144** may be manufacture from any number of pieces.

Referring again to FIG. **6**, the mating surfaces **150** of the mating ends **148** of the terminals **66** define a mating interface **164** of the terminal subassembly **126** where the mating surfaces **150** mate with the corresponding terminals **40** (FIGS. **3-5** and **8**) of the electrical connector **12**. The mating surfaces **150** of the terminals **66** are arranged along the terminal side **156** of the platform **154**. Accordingly, the mating interface **164** of the connector **14** extends on the terminal side **156** of the platform **154**. The mating ends **148** of the terminals **66** are deflectable springs that are configured to deflect generally in the direction of the arrow A when mated with the terminals **40** of the connector **12**.

The mating interface **164** of the terminal subassembly **126** is approximately flat. For example, the mating surface **150** of each of the terminals **66** is approximately flat, at least once the

mating end **148** is deflected after being mated with the corresponding terminal **40**. The mating ends **148**, and thus the mating surfaces **150**, of the terminals **66** are arranged side by side in a row **118**. The mating surfaces **150** of the terminals **66** extend approximately within the same plane **120**. The approximately flat shapes of the mating surfaces **150** and the alignment within the common plane **120** provides the mating interface **164** of the connector **14** as approximately flat. The approximately flat mating interface **164** may provide a wipeable and/or cleanable surface for cleaning the mating surfaces **150** of the terminals **66**. For example, a user may use their thumb, a cloth, and/or the like to wipe across the mating interface **164** to clear debris, dirt, other contaminants, and/or the like from the terminals **66**. Moreover, the approximately flat mating interface **164** may trap less dirt, debris, other contaminants, and/or the like than the mating interfaces of at least some known electrical connectors. The approximately flat mating interface **164** may thus enable the mating surfaces **150** of the terminals **66** to be more reliable and/or be more easily cleaned than the terminals of at least some known electrical connectors. For example, the approximately flat mating interface **164** may enable the mating surfaces **150** of the terminals **66** to be cleaned without damaging the terminals **66**. The approximately flat mating interface **164** may provide the connector **14** with a lower profile than at least some known electrical connectors.

As can be seen in FIG. **6**, the mating ends **148** of the terminals **66** are aligned with corresponding grooves **110** of the grate **155**. The mating ends **148** are configured to be deflected into or further into the corresponding grooves **110** when the mating ends **148** are mated with the terminals **40** of the connector **14**. The ribs **112** of the grate **155** are configured to protect the mating ends **148** of the terminals **66** from over-deflection. Specifically, the common plane **116** (FIG. **7**) of the tip surfaces **114** of the ribs **112** is aligned with a predetermined deflected position of the mating ends **148** that represents a maximum desired deflection of the mating ends **148**. Accordingly, as a structure (e.g., the electrical connector **12**) engages the mating ends **148** of the terminals **66**, the structure will engage the tip surfaces **114** of the ribs **112** such that the structure cannot move the mating surfaces **150** of the mating ends **148** past the tip surfaces **114**. The ribs **112** thus prevent the mating ends **148** from being deflected to or past a position where the mating ends **148** are damaged from being deflected past the working range of the mating ends **148**.

Referring again to FIG. **7**, the metal shell **94** extends a length from a mating end **174** to an opposite terminating end **176**. The metal shell **94** is configured to receive the electrical conductors **142** of the cable **22** through the terminating end **76**. The mating end **174** of the metal shell **94** includes a terminal opening **122**. Optionally, the metal shell **94** includes a groove **182** that receives the sealing ring **106**. The metal shell **94** optionally includes securing features **92** for securing the connector **14** to the connector **12** when the connectors **12** and **14** are mated together. In the illustrated embodiment, the securing features **92** include the pins **92** that are configured to be received by the electrical contacts **90***a* (FIGS. **3** and **8**) of the metal shell **24** (FIGS. **1-5** and **8**) to electrically and mechanically connect the metal shell **24** of the connector **12** to the metal shell **94** of the connector **14**. Other types of securing features **92** may additionally or alternatively be used to electrically and/or mechanically connect the metal shells **24** and **94** together.

The metal shell **94** may include any metallic materials, such as, but not limited to, aluminum, copper, gold, silver, nickel, titanium, magnesium, platinum, another metal, and/or the like. In some embodiments, the metal shell **94** includes an aluminum alloy, a copper alloy, a gold alloy, a silver alloy, a nickel alloy, a titanium alloy, a magnesium ally, a platinum alloy, another metal alloy, and/or the like. Moreover, in some embodiments, an approximate entirety or a majority of the metal shell **94** is fabricated from one or more metals and/or metal alloys. In some embodiments, at least 90% of the metal shell **94** is fabricated from one or more metals and/or metal alloys. In the exemplary embodiment of the metal shell **94**, an approximate entirety of the metal shell **94** is fabricated from one or more metals and/or metal alloys. Optionally, the metal shell **94** includes a base material (not shown) that is coated (e.g., plated and/or the like) with one or more different materials, whether or not the base material and/or the coating includes a metal and/or a metal alloy. One example of fabricating less than an approximate entirety of the metal shell **94** from one or more metals and/or metal alloys includes providing the metal shell **94** with a base material of one or more metals and/or metal alloys that is coated with one or more non-metallic materials, or vice versa. Any non-metallic materials that the metal shell **94** includes may or may not be electrically conductive.

The metal shell **94** is electrically conductive. Specifically, at least a portion of the metal shell **94** is electrically conductive such that the metal shell **94** defines an electrical path through the connector **14**. In some embodiments, an approximate entirety of the metal shell **94** is electrically conductive. In other embodiments, one or more segments (e.g., a coating, a base material, and/or the like) is not electrically conductive. The electrical conductivity of the metal shell **94** enables the metal shell **94** to electrically shield the terminal subassembly **126**. The electrical shielding may prevent or reduce electromagnetic interference (EMI) and/or radio frequency interference (RFI) on the signal paths defined through the connector **14**. Such electrical shielding may allow relatively high speed data to be uninterrupted by the connector **14**. In the illustrated embodiment, the metal shell **94** is manufactured from a single piece, but the metal shell **94** may alternatively be manufactured from two or more pieces that connect together to define the metal shell **94**.

The metal shell **94** has a thickness T_2. The thickness T_2 may have any value. Various parameters of the metal shell **94** may be selected to provide the metal shell **94**, and thus the connector **14**, with a predetermined strength. Examples of such various parameters include, but are not limited to, the thickness T_2, the particular metallic materials of the metal shell **94**, and/or the like. The predetermined strength of the metal shell **94** may reduce the likelihood that the metal shell **94** will structurally fail (e.g., fracture, break, collapse, and/or the like) during use within relatively rugged environments, such as, but not limited to, use when mounted to a wearable article, use within battlefields or other combat situations, field use, use within manufacturing facilities, use within construction sites, and/or the like. The predetermined strength of the metal shell **94** may enable the metal shell **94** to better protect the terminal sub-assembly **126** in relatively rugged environments. The predetermined strength of the metal shell **94** may enable the metal shell **94** to provide an increased amount of protection to the terminal subassembly **126** than at least some known electrical connectors. Examples of the thickness T_2 include, but are not limited to, between approximately 0.5 mm and approximately 2.0 mm, at least approximately 0.5 mm, and/or the like.

The metal shell **94** has the cross-sectional shape of an oval. Specifically, the metal shell **94** has the cross-sectional shape of an oval taken along a cross section that extends approximately perpendicular to the length of the metal shell **94**. The oval cross-sectional shape of the metal shell **24** may facilitate

providing the metal shell **94**, and thus the connector **14**, with a relatively low profile, which may facilitate use of the connector **14** when held by the wearable article. The oval cross-sectional shape of the metal shell **94** may provide the metal shell **94** with a lower profile than at least some known electrical connectors.

Referring again to FIG. **6**, the mating end **174** of the metal shell **94** surrounds the side **158**, the side end **160**, and the side end **162** of the platform **154** of the insulator **144**. The terminal side **158** of the platform **154** is exposed through the mating end **174** of the metal shell **94** such that the mating ends **148** of the terminals **66** are exposed through the mating end **174** of the metal shell **94**. Specifically, the mating surfaces **150** of the terminals **66** are (and thus the mating interface **164** of the connector **14** is) exposed through the terminal opening **122** of the metal shell **94**. The mating interface **164** of the connector **14** is thus exposed for mating with the connector **12**.

In the illustrated embodiment, the connector **14** includes a boot **123** that seals the terminating end **178** of the metal shell **94**. The seal provided by the boot **123** may enable the connector **14** to be water tight. In addition or alternatively, the connector **14** may include a grommet (not shown) and/or the cable **22** may sealingly engage the metal shell **94** to seal the terminating end **178** of the metal shell **94**.

Although six are shown, the connector **14** may include any number of the terminals **66**. Optionally, four of the terminals **66** may be configured to operate at any USB standard, protocol, and/or the like, such as, but not limited to, USB 1.0, USB 2.0, USB 3.0, and/or the like.

FIG. **8** is a cross-sectional view of the electrical connector system **10** illustrating the electrical connectors **12** and **14** mated together. The metal shell **94** of the connector **14** is received within the open mating end **74** of the tunnel **80** of the connector **12**. The mating surfaces **150** of the terminals **66** of the connector **14** are engaged with the mating surfaces **50** of the corresponding terminals **40** of the connector **12** such that the terminals **66** are electrically connected to the corresponding terminals **40**. The connectors **12** and **14** thus mate together within the tunnel **80** to establish an electrical connection between the electrical conductors **42** of the cable **20** and the electrical conductors **142** of the cable **22**. The sealing ring **106** of the connector **14** is sealingly engaged with the interior surface **102** of the tunnel **80** to seal the open mating end **174** of the tunnel **80**. The seal provided by the sealing ring **106** may provide the mated interface between the connectors **12** and **14** within the tunnel as water tight.

The electrical contacts **90***a* of the metal shell **24** of the connector **12** are engaged with the electrical pins **92***a* of the metal shell **94** of the connector **14** such that the metal shells **24** and **94** are electrically and mechanically connected together. Although the electrical pins **92***a* engage the electrical contacts **90***a* with a snap-fit connection in the illustrated embodiment, any other type of connection may additionally or alternatively be used. The mechanical connection between the electrical contacts **90***a* and the electrical pins **92***a* may provide a visual indication that the connectors **12** and **14** are fully mated together. The electrical connection between the metal shells **24** and **94** enables the metal shells **24** and **94** to electrically shield the connector system **10**, which may prevent or reduce electromagnetic interference (EMI) and/or radio frequency interference (RFI) on the signal paths defined through the connector system **10**. Such electrical shielding may allow relatively high speed data to be uninterrupted by the connector system **10**.

It is to be understood that the above description is intended to be illustrative, and not restrictive. For example, the above-described embodiments (and/or aspects thereof) may be used in combination with each other. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from its scope. Dimensions, types of materials, orientations of the various components, and the number and positions of the various components described herein are intended to define parameters of certain embodiments, and are by no means limiting and are merely exemplary embodiments. Many other embodiments and modifications within the spirit and scope of the claims will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects. Further, the limitations of the following claims are not written in means—plus-function format and are not intended to be interpreted based on 35 U.S.C. §112, sixth paragraph, unless and until such claim limitations expressly use the phrase "means for" followed by a statement of function void of further structure.

What is claimed is:

1. An electrical connector system comprising:

a first connector having a first terminal subassembly and a first metal shell, the first terminal subassembly being held by the first metal shell and comprising a first group of terminals, the first metal shell comprising a sealing ring; and

a second connector configured to mate with the first connector, the second connector having a second metal shell and a second terminal subassembly that is held by the second metal shell, the second terminal subassembly comprising a second group of terminals that is configured to mate with the first group of terminals of the first connector, the second metal shell comprising a terminating segment and a tunnel that extends outward from the terminating segment, the tunnel having an open end defined by at least one interior surface of the tunnel, the first metal shell being configured to be received within the open end of tunnel such that the first and second connectors mate together within the tunnel, wherein the sealing ring is configured to sealingly engage with the interior surface of the tunnel to seal the open end of the tunnel when the first and second connectors are mated together within the tunnel;

wherein the first connector is configured to terminate to a plurality of electrical conductors, the first terminal subassembly having an insulator that includes grooves and ribs, the ribs extending between adjacent grooves, the first group of terminals being held by the insulator, the first group of terminals having terminating ends that are configured to be electrically connected to the electrical conductors, the first group of terminals having mating ends that include mating surfaces where the first group of terminals are configured to mate with the second connector, the mating ends being deflectable springs that are aligned with corresponding grooves in the insulator, the mating ends being deflectable into the corresponding grooves, wherein the ribs are configured to protect the mating ends of the first group of terminals from over-deflection.

2. The electrical connector system of claim **1**, further comprising a holder configured to be secured to a wearable article,

the holder comprising a shroud that defines a chamber of the holder, the second metal shell being held by the holder within the chamber, the tunnel extending within the chamber outward from the terminating segment of the second metal shell toward an entrance to the chamber.

3. The electrical connector system of claim **1**, wherein at least one of the first connector or the second connector comprises at least one of a grommet or a boot that is configured to seal a terminating end of the first or second metal shell, respectively.

4. The electrical connector system of claim **1**, wherein the tunnel is an integral structure of the second metal shell.

5. The electrical connector system of claim **1**, wherein the first and second connectors comprises securing features that when mechanically connected together provide a visual indication that the first and second connectors are fully mated together.

6. The electrical connector system of claim **1**, wherein the first metal shell comprises a mating end and an opposite terminating end, the first connector further comprising at least one of a grommet or a boot engaged with the first metal shell at the terminating end for sealing the first metal shell to the electrical conductors at the terminating end.

7. The electrical connector system of claim **1**, wherein the second connector is configured to terminate to a plurality of electrical conductors, the second group of terminals configured to be electrically connected to the electrical conductors, the second terminal subassembly having an insulator holding the second group of terminals, the second terminal subassembly having a mating interface where mating surfaces of the second group of terminals mate with the first connector, the mating interface being approximately flat, the second metal shell of the second connector that holds the second terminal subassembly having the cross-sectional shape of an oval.

8. The electrical connector system of claim **7**, wherein the insulator of the second terminal subassembly comprises a platform, the mating surfaces of the second group of terminals being arranged along the platform such that the mating interface of the second terminal subassembly extends on the platform, the tunnel of the second metal shell surrounding the platform, wherein the tunnel is spaced apart from the platform along at least three sides of the platform.

9. The electrical connector system of claim **7**, wherein the mating surfaces of the second group of terminals are approximately flat and are arranged side by side within approximately the same plane to define the approximately flat mating interface of the second terminal subassembly.

10. The electrical connector system of claim **1**, further comprising a holder configured to be mounted to a wearable article, the second metal shell of the second connector being held by the holder such that the second connector is configured to be held by the wearable article.

11. The electrical connector system of claim **1**, wherein at least one of the first metal shell or the second metal shell has the cross-sectional shape of an oval, the oval cross-sectional shape being at least one of oblong, elliptical, a rectangle with rounded corners, or the shape of an egg.

12. The electrical connector system of claim **1**, wherein at least one of the first group of terminals or the second group of terminals are electrically connected to electrical conductors, the electrical conductors being at least one of electrical conductors of a cable or electrical conductors of an e-textile.

13. The electrical connector system of claim **1**, wherein the ribs comprise tip surfaces that extend approximately within a common plane, the common plane of the tip surfaces being aligned with a predetermined deflected position of the mating surfaces of the first group of terminals that represents a maximum desired deflection of the mating ends of the first group of terminals.

14. The electrical connector system of claim **1**, wherein the insulator of the first terminal subassembly comprises a platform having a terminal side, an opposite side, and two side ends that extend from the terminal side to the opposite side, the mating ends of the first group of terminals being arranged along the terminal side of the platform, the first metal shell surrounding the side ends and the opposite side of the platform, the terminal side of the platform being exposed through the first metal shell such that the mating surfaces of the first group of terminals are exposed for mating with the second connector.

15. The electrical connector system of claim **1**, wherein the first metal shell has the cross-sectional shape of an oval.

16. The electrical connector system of claim **1**, wherein the second terminal subassembly has a mating interface where mating surfaces of the second group of terminals mate with the first connector, the mating surfaces of the second group of terminals are approximately flat and are arranged side by side within approximately the same plane such that the mating interface is approximately flat.

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